MEMS MWD gyro (GDIS)Field test analysis

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Wellbore Positioning Technical Section

The Industry Steering Committee on Wellbore Survey Accuracy (ISCWSA)

Speaker Bio

- Introduction
  - Schlumberger Drilling and Measurements
  - 20+ yrs in O&G industry 17 yrs in wellbore surveying
  - MSc in Drilling and Well Engineering
  - Houston
  - Specialized in
    - Wellbore surveying
      - Directional Drilling
        - Hydrographic surveying

GDIS field test results Agenda

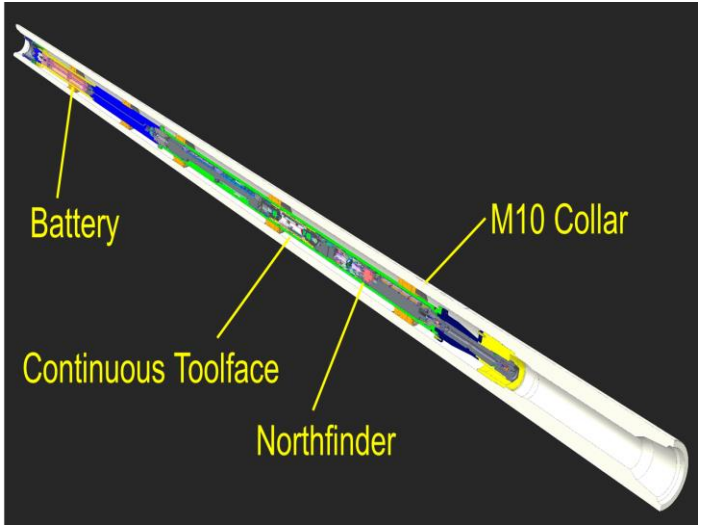
GMWD Field test results presented by Ross Lowdon

- GDIS Introduction
  - Calibration and QC
- GDIS test parameters
- GDIS field test results
  - Run Summary
  - GDIS QC
  - Survey comparison methodology
  - Definitive survey comparisons
- Conclusions and Further work

GDIS field test results
GDIS Introduction

GMWD Field test results presented by Ross Lowdon

- GDIS
  - MEMS solid state gyro
  - Robust and low power
  - Traditionally low accuracy
  - 3 axis gyro reduced noise level
  - Accurate flipping mechanism
  - 2 minute survey time (Best survey pumped up)
  - Continuous TF during sliding (3 axis gyro)
  - Multiple surveys on every connection
  - Module based system
  - RPM/downlink/Pumps off survey triggers



GDIS field test results
GDIS Survey QC and Calibration

GMWD Field test results presented by Ross Lowdon

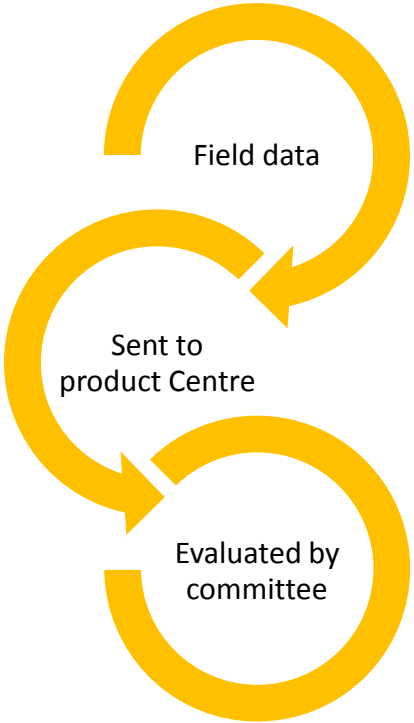
- QC
  - Earth Rate
  - Latitude
  - Standard deviation Indicator (through rotation cycle)
  - Shock & Vibration indicator
  - Standard Deviation

- Calibration
  - True North referenced stand
  - Tool rotated at known references
  - RT and HT

GDIS field test results
GDIS Test Parameters

GMWD Field test results presented by Ross Lowdon

- GDIS Test parameters
  - Setting up for success
  - Run in memory mode
  - Run on platforms
  - Multiple locations
  - Variation in inclination and azimuth
  - Temp limitation
  - Develop empirical and lab based error model



GDIS field test results
GDIS run summary

GMWD Field test results presented by Ross Lowdon

- 21 wells
- 26 runs
- 1300 operation hrs
- 110C max temp
- 95k ft drilled
- 1 mis-run

GDIS field test results
GDIS survey comparison methodology

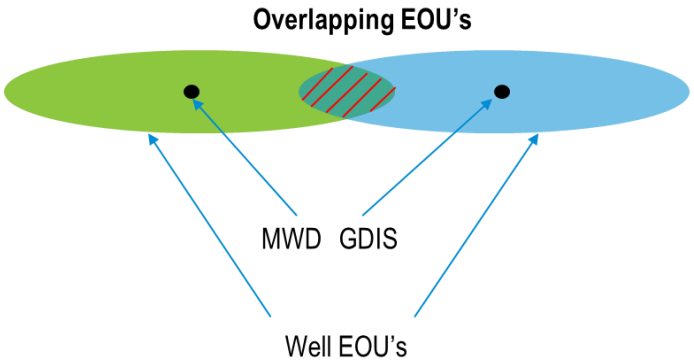
GMWD Field test results presented by Ross Lowdon

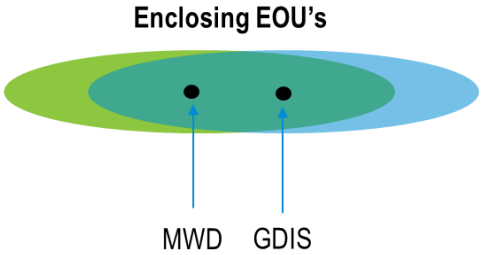
- Multiple surveys at connection
  - All QC accepted surveys averaged
- GDIS survey compared with Definitive surveys
  - Gyro and or MWD
- GDIS EOU's use GDIS empirical error model
  - Validated by the 19 and counting data sets processed
- Average delta's and Standard deviations reviewed
  - Systematic offsets and random noise

GDIS field test results
GDIS survey comparison methodology

GMWD Field test results presented by Ross Lowdon

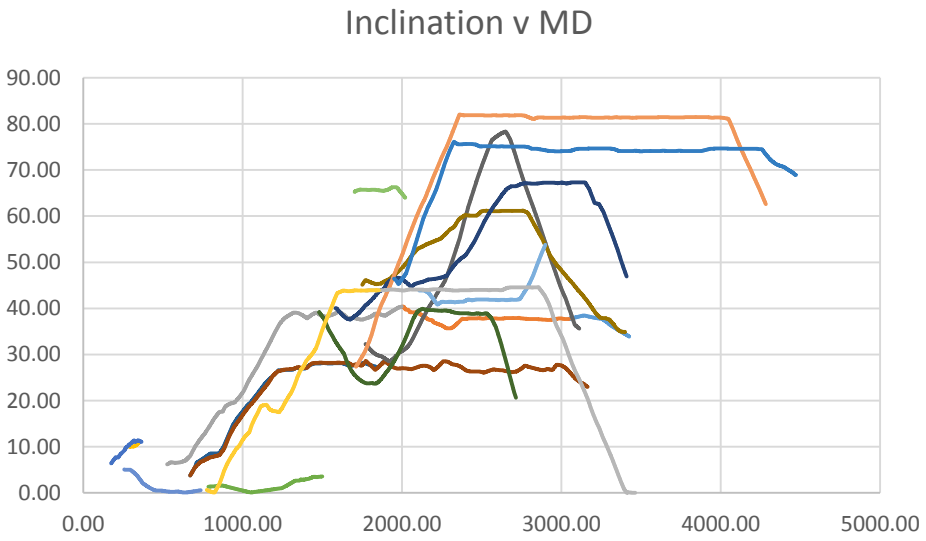
- EOU overlap and inclusion (EOU's similar sizes)
- Statistically EOU overlap = EOU verification
- Realistically EOU inclusion significantly improves confidence

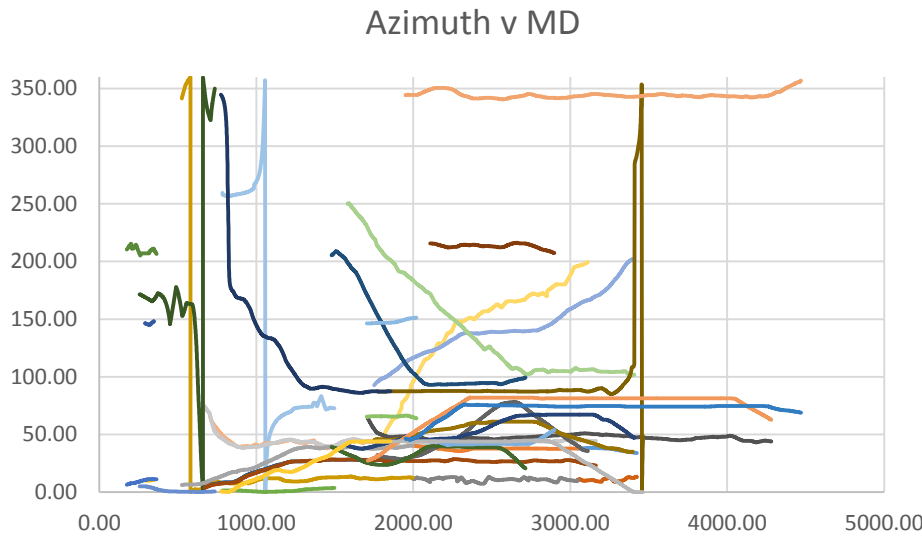




GDIS field test results
GDIS Run orientations and MD

GMWD Field test results presented by Ross Lowdon





GDIS field test results
GDIS definitive survey comparisons

GMWD Field test results presented by Ross Lowdon

	Semi Maj	TVD error	Lateral Dist	TVD Dist	EOU Overlap	EOU inclusion	Incl AVE Delta	Incl STDEV	Azi AVE Delta	Azi STDEV
run 1	40.47	6.65	69.73	12.62	Yes	No	0.13	0.39	1.29	3.15
run 2	17.48	3.39	5.73	0.01	Yes	Yes	0.00	0.12	1.05	1.13
run 3	14.93	5.52	1.58	-1.48	Yes	Yes	-0.13	0.18	0.03	1.96
run 4	21.49	2.60	9.24	-2.53	Yes	Yes	-0.12	0.11	-0.12	1.96
run 5	23.61	3.45	9.55	0.00	Yes	Yes	0.00	0.12	-0.41	1.18
run 6	2.07	1.10	0.17	0.00	Yes	Yes	0.11	0.08	0.10	72.15
run 7	6.37	3.64	5.98	0.86	Yes	Yes	0.01	-0.24	0.42	1.26
run 8	21.65	6.35	7.36	0.64	Yes	Yes	0.03	0.09	-0.55	1.02
run 9	43.48	9.50	3.05	9.41	Yes	Yes	0.17	0.10	0.32	0.87
run 10	22.05	5.16	1.58	0.96	Yes	Yes	0.10	0.22	0.13	1.22
run 11	26.78	6.81	1.46	-1.33	Yes	Yes	-0.11	0.13	0.02	1.75
run 12	4.71	2.99	0.67	0.01	Yes	Yes	0.08	0.11	0.47	59.91
run 13	6.97	4.41	4.59	1.05	Yes	Yes	0.05	0.32	0.47	0.29
run 14	13.27	9.31	8.65	-0.32	Yes	Yes	0.02	0.18	0.55	0.76
run 15	1.35	1.14	1.87	-0.33	Yes	No	0.55	0.27	-0.86	2.03
run 16	1.02	1.12	0.28	-0.05	Yes	Yes	0.26	0.11	-0.09	1.46
run 17	6.97	4.41	5.22	1.05	Yes	Yes	0.10	0.18	0.43	0.70
run 18	9.24	7.07	8.50	-1.67	Yes	Yes	0.01	0.27	0.79	1.15
run 19	13.77	9.57	9.83	-1.12	Yes	Yes	-0.14	0.11	0.91	0.96

GDIS field test results
Conclusions

GMWD Field test results presented by Ross Lowdon

- Accurate MEMS gyro while drilling
- GDIS data comparable with MWD and other gyro systems
- Reduced calibration requirement
- GDIS reliable and robust
- Scope for accuracy improvement

Further work

- Implement specific GDIS running procedures
- Add functionality